RNA and PROTEIN SYNTHESIS

Chapter 13

DNA

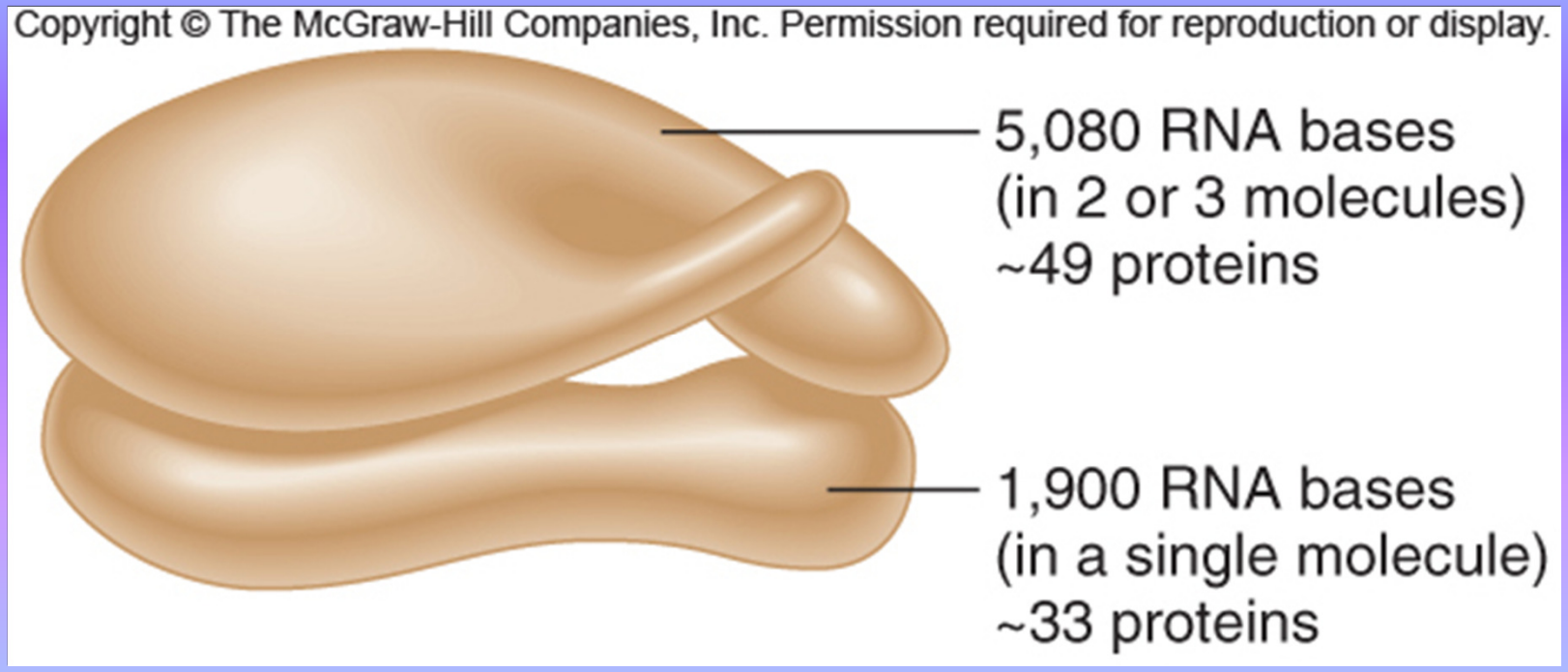
- Double stranded
- Thymine
- Sugar is Deoxyribose

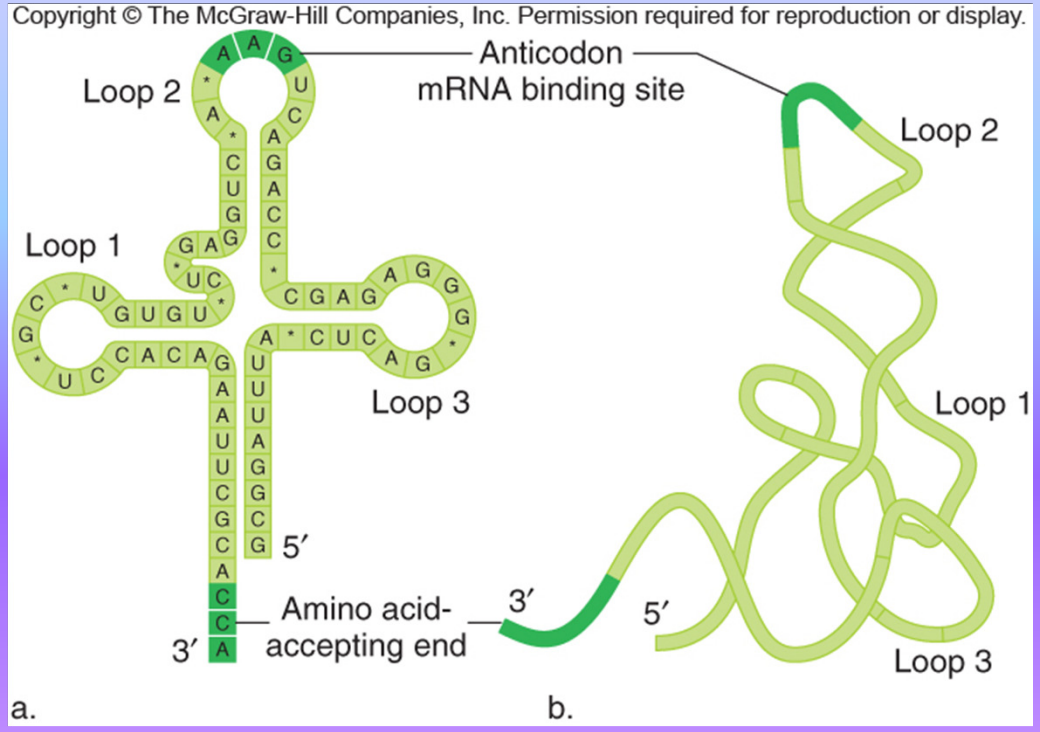
RNA

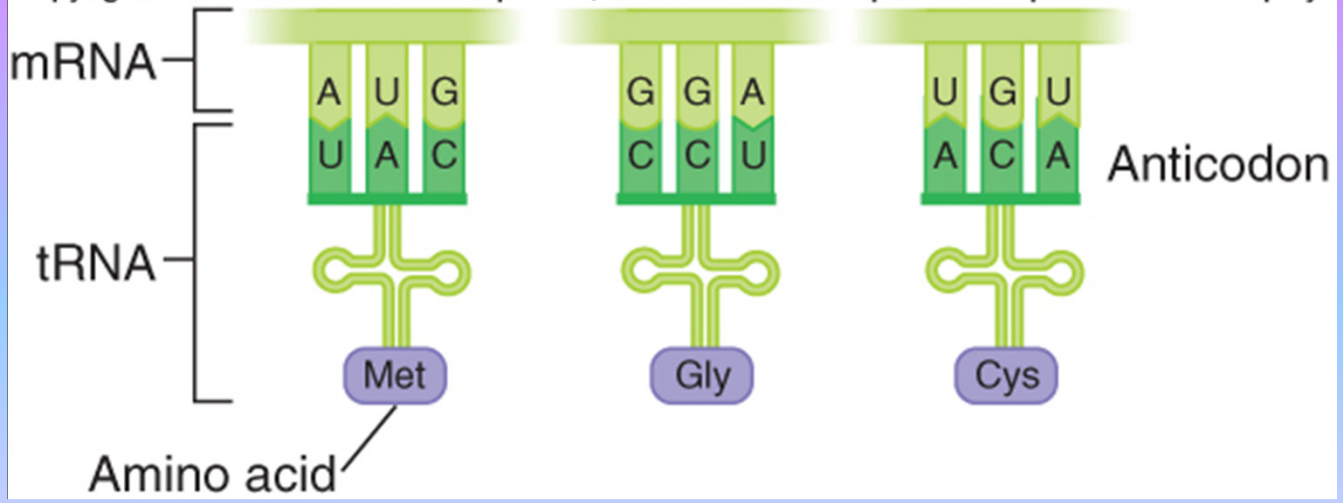
- Single stranded
- Uracil
- Sugar is Ribose

- Types of RNA
  1. Messenger RNA (mRNA)
     - Carries copies of instructions from DNA to ribosomes
  2. Ribosomal RNA (rRNA)
     - Important component of ribosomes
  3. Transfer RNA (tRNA)
     - Carries amino acids to ribosomes during protein synthesis

rRNA

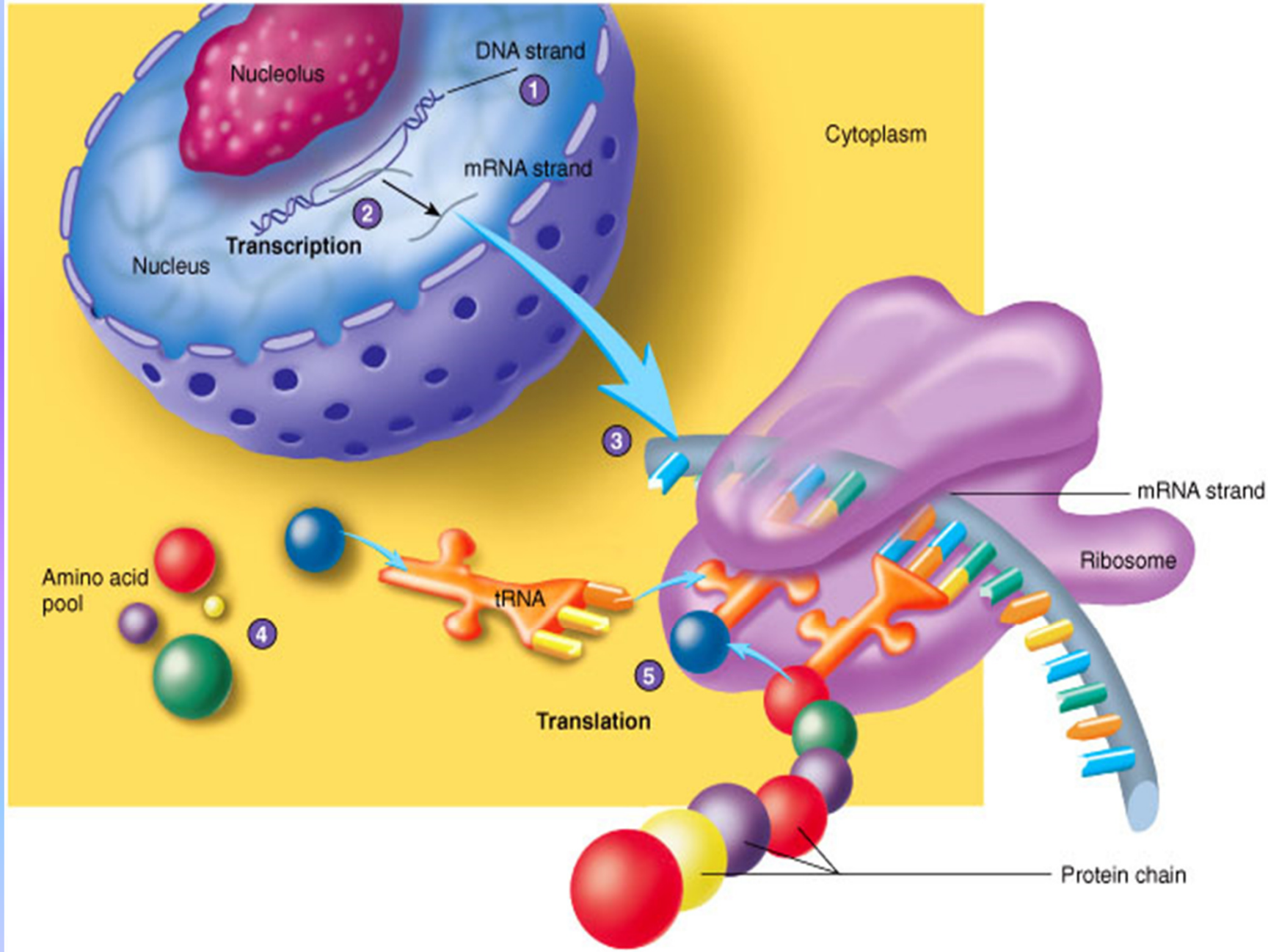






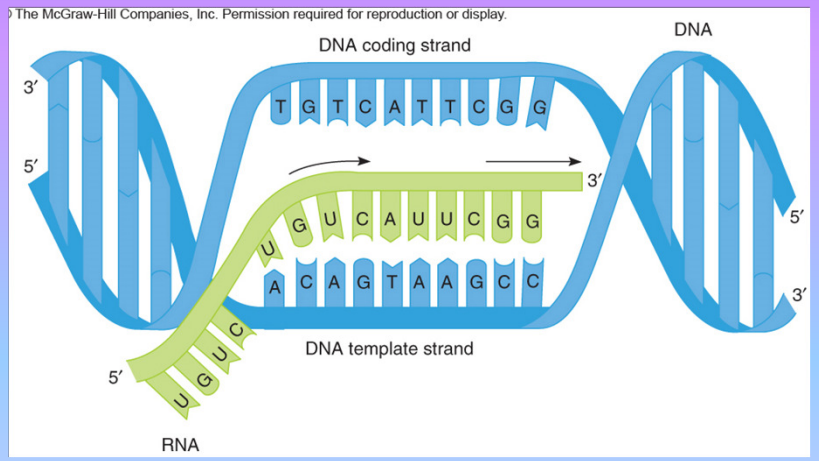
- ***Transcription*** =
  - Synthesis of RNA from DNA template
  - Eukaryotes
    - Occurs in nucleus
  - Prokaryotes
    - Occurs in cytoplasm

- ***Translation*** =
  - mRNA is converted into sequence of amino acids of a protein
  - Eukaryotes AND prokaryotes
    - Occurs in cytoplasm at ribosomes



RNA Synthesis: Transcription

- ***Promoter*** =
  - Specific region of a gene where RNA polymerase binds and begins transcription
- ***RNA polymerase*** =
  - Enzyme that links RNA nucleotides using DNA as a template
    - Adds complementary RNA nucleotides along DNA template strand



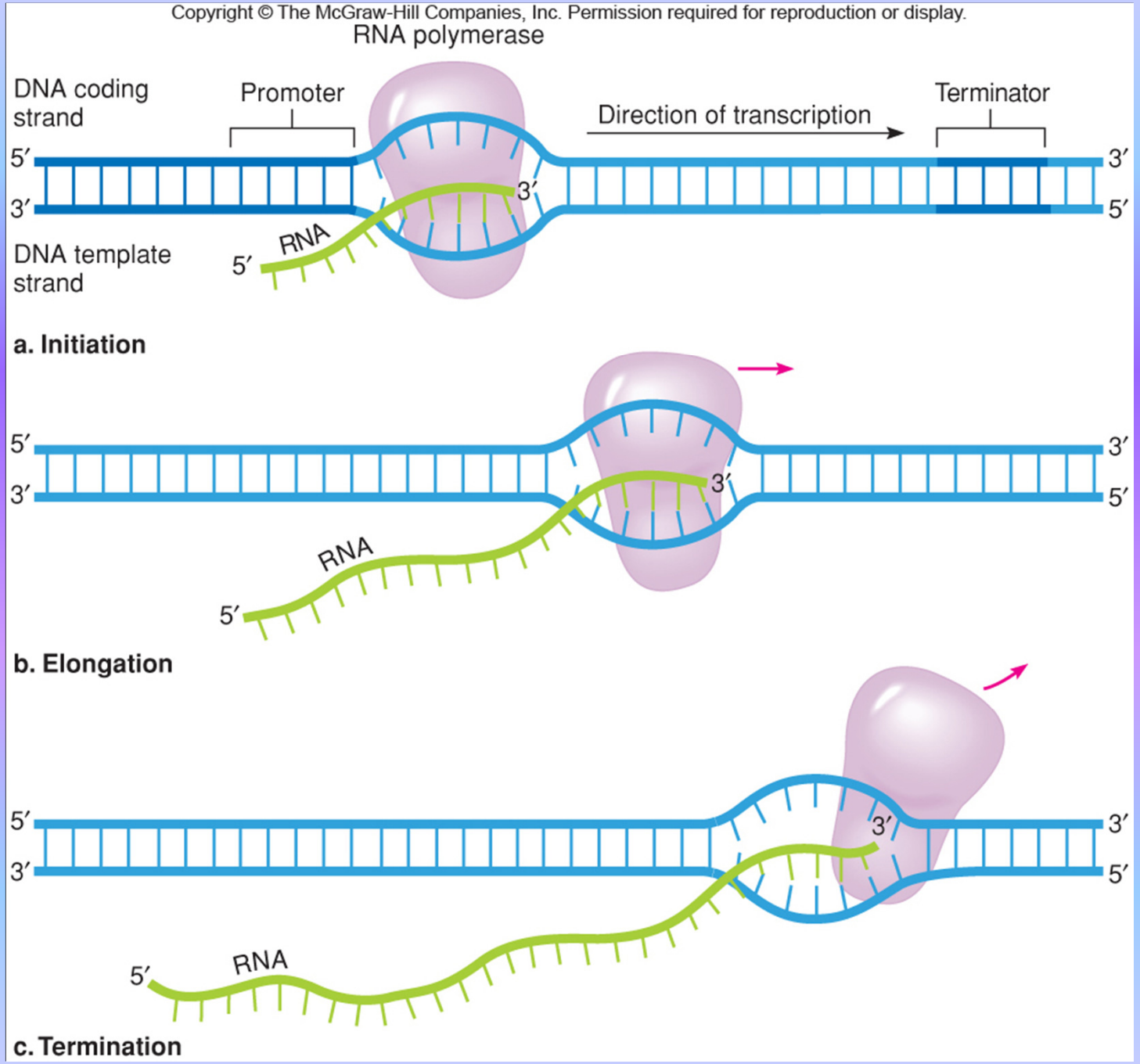
-RNA's **C** pairs with DNA's **G**

-RNA's **G** pairs with DNA's **C**

-RNA's **A** pairs with DNA's **T**

*-RNA's **U** pairs with DNA's **A***

- Synthesized in 5' to 3' direction



Let's Practice!

- DNA template strand

C C T A G C T A C

- RNA

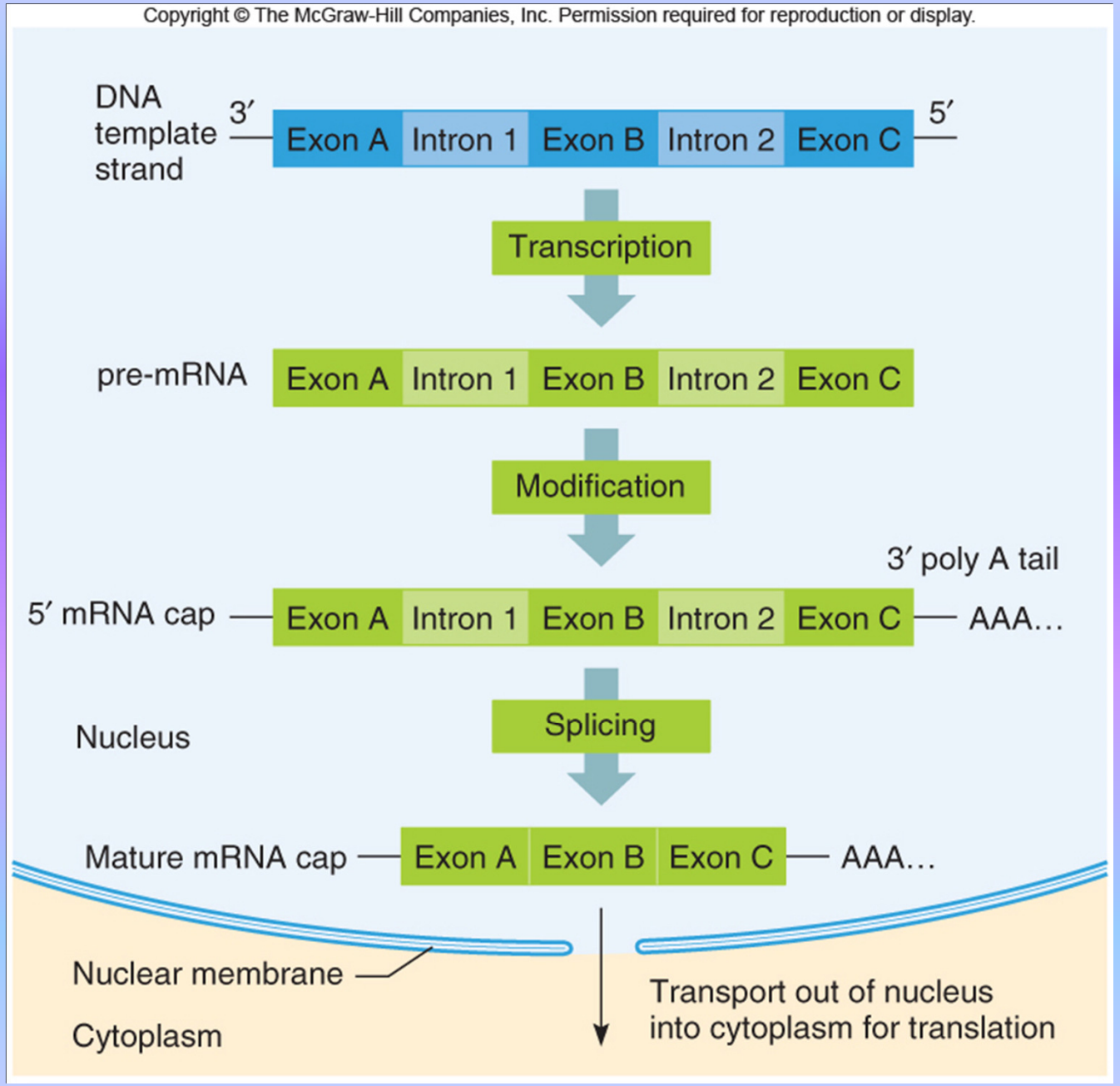
G G A U C G A U G

- DNA coding strand

G G A T C G A T G

RNA Editing

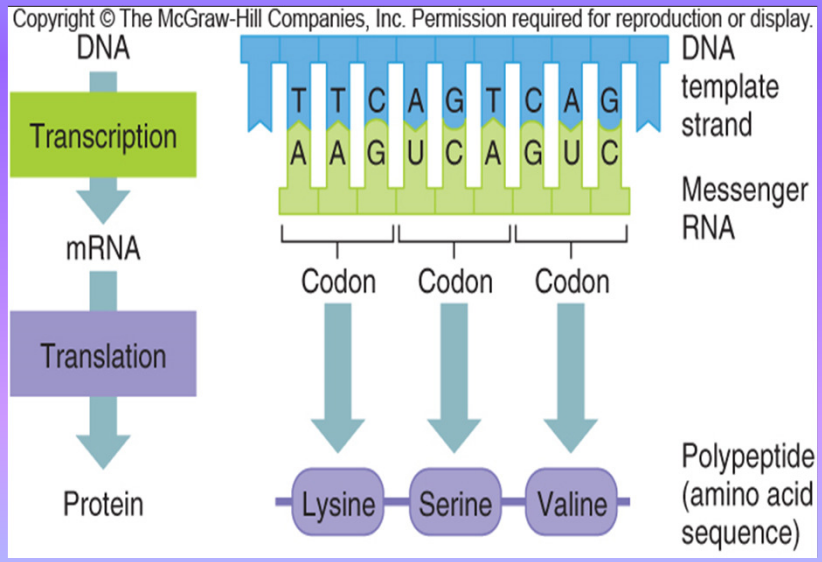
- ***Introns*** =
  - Sequences of DNA that are not involved in coding for a protein
  - Transcribed but then removed before translation
- ***Exons*** =
  - Sequences of DNA that code for proteins
  - Spliced back together to be translated
- Cap is added to 5' end
  - Recognition site for protein synthesis
- Poly A tail is added to 3' end
  - Necessary for protein synthesis to begin
  - May also stabilize mRNA so it stays intact longer
- Mature mRNA exits the nucleus to be translated

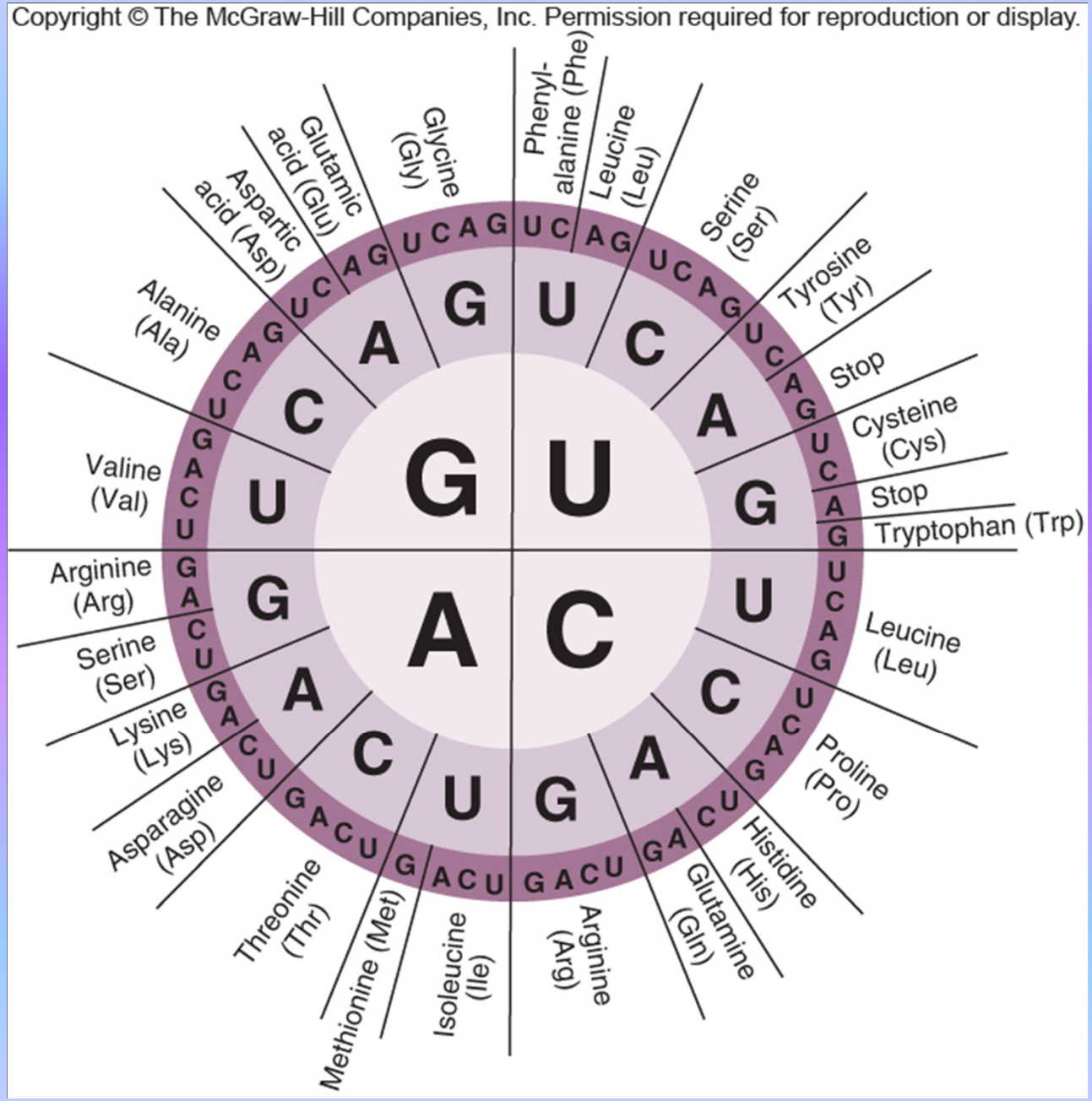


Protein Synthesis: Translation

Genetic code =

- Correspondence between specific mRNA triplets and the amino acids they specify
- ***Codon*** =
  - Group of **3** nucleotide bases in **mRNA** that specify a particular amino acid
  - AUG is the "start" codon
  - UGA, UAA, and UAG are "stop" codons
- Universal
  - All species use the same mRNA codons to specify the same amino acids





Let's Practice!

- mRNA

  AUGGGAUGUAAGCGAUAA

- mRNA codons

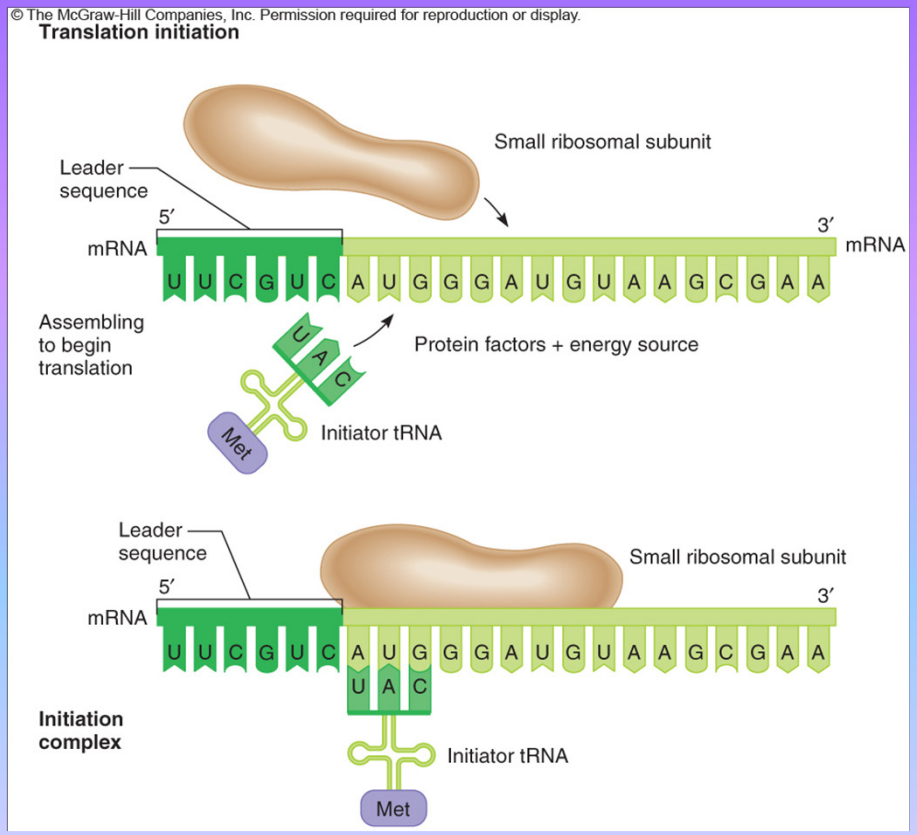
  AUG GGA UGU AAG CGA UAA

- Amino Acid

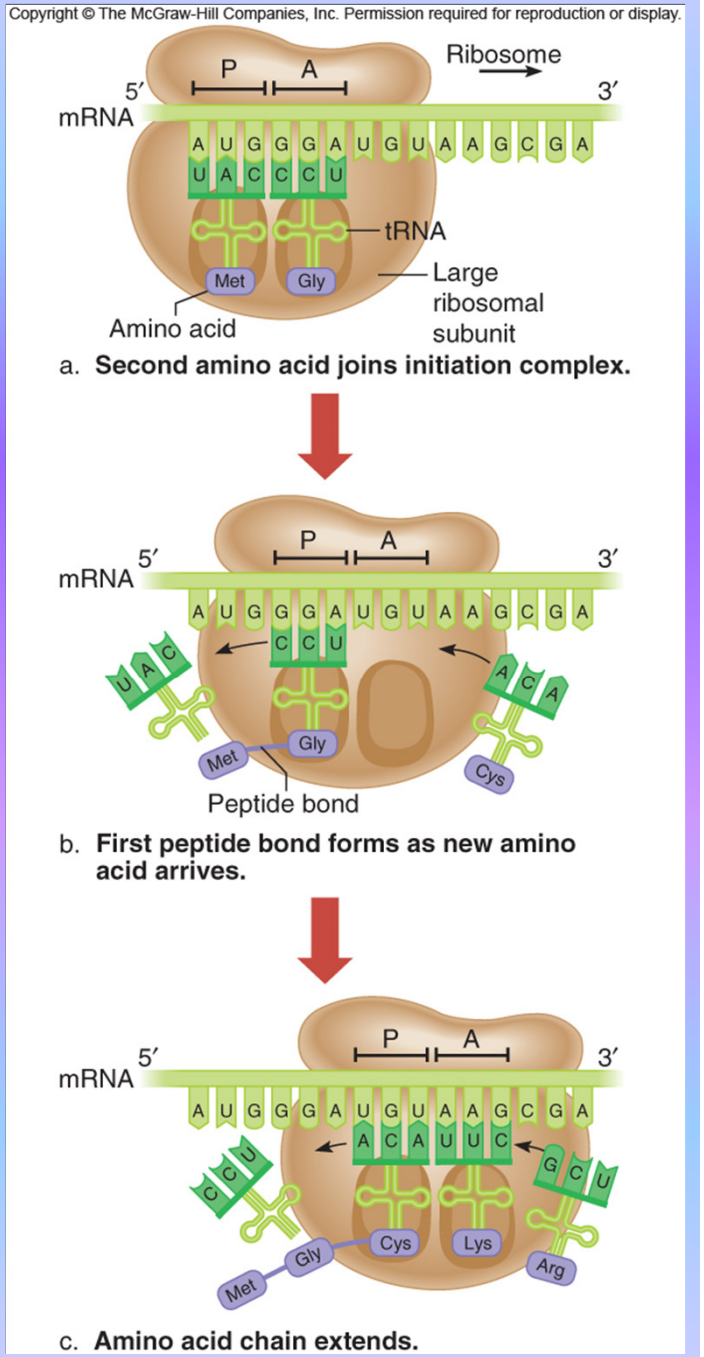
  Met Gly Cys Lys Arg (STOP)

Steps in Translation to Build a Protein

- Ribosome attaches to mRNA in cytoplasm
- Proper amino acids are brought to codons with help of ***anticodons*** =
  - Group of **3** bases on **tRNA** that are complementary to mRNA codon and carry appropriate amino acid



- Start codon (AUG) attracts tRNA carrying the amino acid methionine (Met)
  - Indicates start of polypeptide
- tRNA brings next amino acid to A site of ribosome
- P site next to it holds growing amino acid chain
  - ***Peptide bond*** forms between adjacent amino acids, creating a ***polypeptide chain***
- When "Stop" codon reaches the A site, the new polypeptide and mRNA are released



Let's Practice!

- DNA

  TACGGTCGTTCGAATATC

- mRNA codons

  AUG CCA GCA AGC UUA UAG

- tRNA anticodons

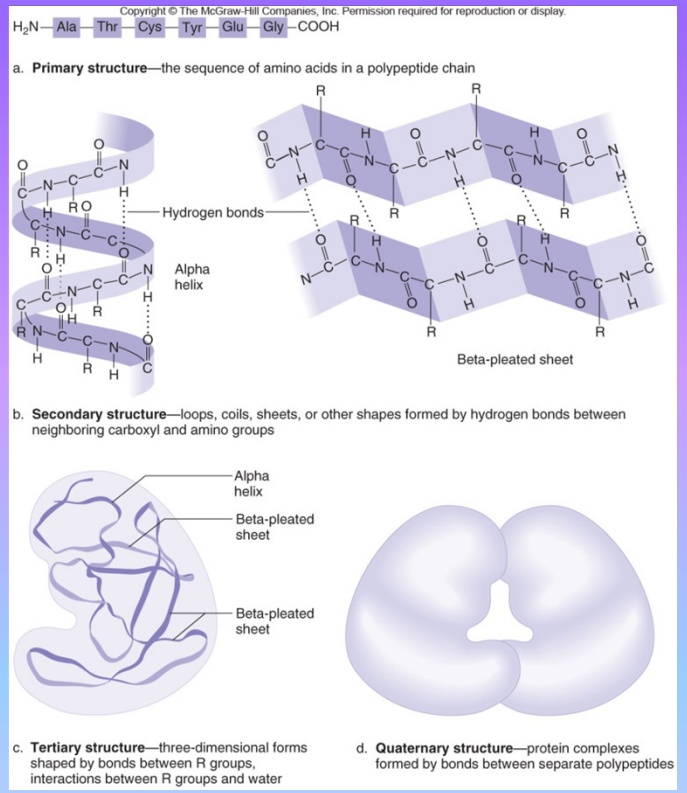
  UAC GGU CGU UCG AAU AUC

- Amino Acid (remember to use the codons!)

  Met Pro Ala Ser Leu (STOP)

Protein Modification

- Proteins fold into one or more 3-D shapes
  - Remember, shape affects function!
- ***Chaperone proteins*** =
  - Binds a polypeptide and guides folding
- ***Proteasome*** =
  - Refolds or dismantles misfolded proteins
- Example of folding error:
  - Sickle cell disease
    - Red blood cells are bent out of shape



Mutations

- ***Mutation*** =
  - Change in the genetic material of a cell
    - Alters DNA sequence
    - May or may not affect phenotype
  - 2 basic categories:
    - Chromosomal mutations
    - Gene mutations
      - ***Point mutations*** =
        - » Single base pair in DNA is changed
        - » Generally occur during replication
        - » Ex: Substitutions, insertions, deletions

- ***Substitution*** =
  - One base is changed to a different base
  - Results in change of one codon
  - Examples
    - ***Missense mutation*** =
      - One amino acid is altered
    - ***Nonsense mutation*** =
      - Protein is shortened because new codon is a "STOP" codon
    - ***Silent mutation*** =
      - No change in amino acid
      - 3rd base of triplet was altered to codon that specifies the same amino acid

- ***Frameshift mutations*** =
  - Shifts “reading frame” of genetic message
  - Alters every amino acid that follows the mutation
  - Examples
    - ***Insertion*** =
      - One base is added to DNA sequence
    - ***Deletion***
      - One base is removed from DNA sequence
- Note: If bases are inserted/deleted in multiples of 3, reading frame is not altered

Effects of mutations

- ***Mutagens*** =
  - Agents in environment that interact with DNA and may cause a mutation by:
    - Interfering with base pairing
      - Increases errors in DNA replication
    - Weakening DNA strand
      - Causes breaks and inversions on chromosomes
  - Examples
    - Chemical
      - Pesticides, tobacco smoke, environmental pollutants
    - Physical
      - Radiation (X rays, UV light)

- Harmful effects
  - Cancer and other genetic disorders
- Beneficial effects
  - Resistance
  - ***Polyploidy*** = extra sets of chromosomes
    - Results in larger and stronger plants
  - Increase genetic variability in a species
- Many mutations are neutral
  - May not even change any amino acids

Gene Regulation and Expression

Prokaryotes

- DNA binding proteins regulate genes by controlling transcription
  - Switch genes on and off
- ***Operon*** =
  - Group of genes that are regulated together
  - Ex: *Lac* operon
    - If lactose is not present, *lac* genes are turned off

- ***Promoter*** =
  - Site where RNA-polymerase binds to begin transcription
- ***Operator*** =
  - Site where *lac* repressor can bind to DNA
  - Lies between promoter and operon
    - If *lac* repressor binds to operator
      - Operon is turned off
    - If lactose is present, it removes repressor
      - Operon is turned on

Eukaryotes

- ***Transcription factors*** =
  - Proteins that activate the transcription of certain genes
    - Open up tightly packed chromatin
    - Block access to certain genes
    - Attract RNA polymerase via TATA box (promoter)
      - Control sequence near the start of a gene
      - Composed of bases TATA surrounded by long stretches of G and C

- Gene regulation helps cells undergo ***differentiation*** =
  - Cells become specialized in structure and function
- ***Homeotic genes*** =
  - Regulate organs that develop in specific parts of the body
  - Mutation can transform one body part into another
  - ***Homeobox gene*** =
    - Codes for transcription factors that activate genes important in cell development and differentiation
    - Determine factors like presence of wings or legs

Environmental Influences

- Environmental conditions also play a role in gene expression
  - Temperature
  - Salinity
  - Nutrient availability